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DEVELOPMENT AND IMPROVEMENT OF CONVEYOR TRANSPORT IN THE CONDITIONS OF COMPLICATED OPERATION IN MODERN MINING INDUSTRY

Summary. This article gives a description of existing and future developments of special types of belt conveyors (for example, multidrive, high-angled, overhead conveyors) for complicated conditions, when application of conventional conveyor is irrational or impossible. It is considered improving design of the belt conveyors through the development of the intermediate drive construction as the optimal solution of the traction transferring problems, with increased traction transferring efficiency of the intermediate linear drive on inclined and curving route sections, and especially in the inclined conveyor. The features of new, ready for application design of special conveyor types, such as high-angled conveyors and overhead conveyors have been described. The rational area of their application in the industry is given. Recommendations to reduce costs in the development, use and operation of conveyor transport in emerging modern mining are given.

Keywords: conveyor, high angle, belt, complicated operation, overhead, vacuum drive, magneto frictional drive.

ROZBUDOWA I MODERNIZACJA TRANSPORTU PRZENOŚNIKOWEGO W ZŁOŻONYCH UWARUNKOWANIACH, W NOWOCZESNYM PRZEMYŚLE GÓRNICZYM

Streszczenie. W niniejszym artykule opisano istniejące i przyszłe udoskonalenia specjalnych typów przenośników taśmowych (np. wielobębnowy,

z dużym kątem nachylenia, pionowy) montowanych w trudnych warunkach, kiedy zastosowanie konwencjonalnego przenośnika nie jest racjonalne lub możliwe. Autorzy rozważają ulepszenie projektu przenośników taśmowych przez udoskonalenie konstrukcji pośredniej przekładni, jako optymalnego rozwiązania problemów z przeniesieniem siły ciągu, przy wzroście wydajności przenoszenia siły ciągu pośredniego napędu liniowego na sekcjach ze wzniesieniami lub o zakrzywionej trasie, w szczególności dla przenośników z nachyloną taśmą. W artykule opisano cechy nowych projektów specjalnych typów przenośników gotowych do wdrożenia, takich jak z dużym kątem nachylenia i pionowe. Zidentyfikowano racjonalny obszar ich zastosowania w przemyśle oraz przedstawiono rekomendacje dotyczące zredukowania kosztów udoskonalenia, użytkowania i działania transportu przenośnikowego w nowoczesnym, rozwijającym się górnictwie.

Słowa kluczowe: przenośnik, wysokie nachylenie, taśma, skomplikowane funkcjonowanie, koszty stałe, napęd próżniowy, napęd magnetofrykcyjny.

1. Introduction

Belt conveyors are widely used in mining enterprises. The advantages of belt conveyors include high capacity, relatively low energy consumption of transportation in comparison with other types of conveyor transport, high degree of automation control the operation of the equipment, relatively low cost of transportation. These advantages cause widespread use of belt conveyors in all fields of industry. However, belt conveyors have a number of disadvantages such as the inability to transport materials by the route, which has short-radius bend, low limit angle of track inclination to the horizon (up to 20 degrees), the high cost of the conveyor belt over a short period of its service life [3,7].

Nowadays there are a lot of new applications of conveyors for special operating conditions. The most common of these applications are overhead belt conveyors and high angle (vertical) conveyors. These types of conveyors have a number of benefits over conventional belt conveyors [2, 6].

2. High angle conveyors

There are various designs of high angle (vertical) conveyors; they may comprise alternating horizontal or inclined sections with angles of inclination from 0 to 90 degrees, which allows solving the logistical problems within and beyond the frame. Such problems are usually solved by a joint effort of several types of equipment.

Schemes of these conveyors are presented in Figure 1.

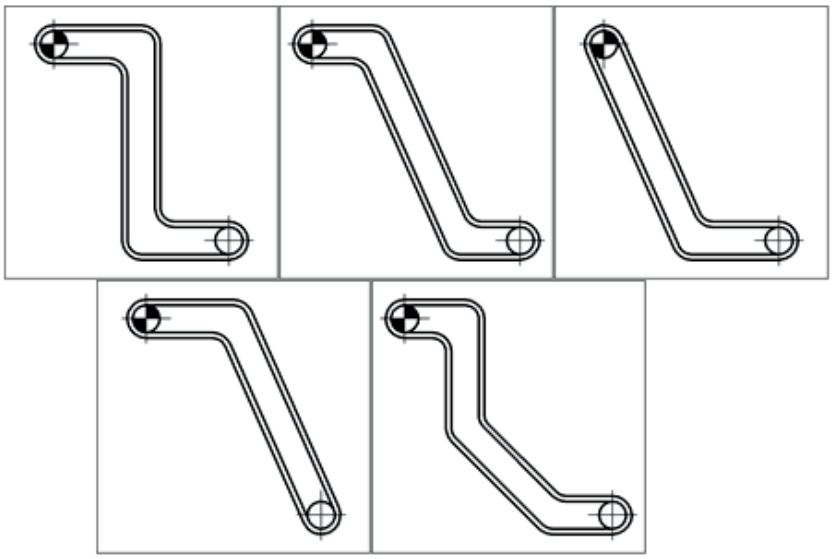

Fig. 1. Schemes of high angle (vertical) conveyors
Rys. 1. Schemat przenośników o dużym kącie nachylenia (pionowych)
Source: Lewis A., Grebenshchikov A.L.: Transportirovaniye nasypnykh materialov konveyyerami bol'shoy protyazhennosti [Transportation of bulk materials of long conveyors]. Gornaya promyshlennost' [Mining] No. 5, 2003.

Typically, high-angle conveyors consist of a horizontal section where the loading of carrying material is performed; inclined or vertical section, and a horizontal section where the unloading takes place. Basic components of these conveyors are almost the same as the components of conventional belt conveyors. Their distinguishing feature is the special design of the conveyor belt, which allows the conveying of the transported material on inclined or vertical sections of the route. Conveyor belt for the high angle conveyor consists of a main rubber-fabric belt, which is a conventional conveyor belt, it can be applied to other types of conveyors; and also profiles and sidewalls attached to base fabric by means of hot or cold vulcanization. Figure 2 shows the high angle conveyor belt.

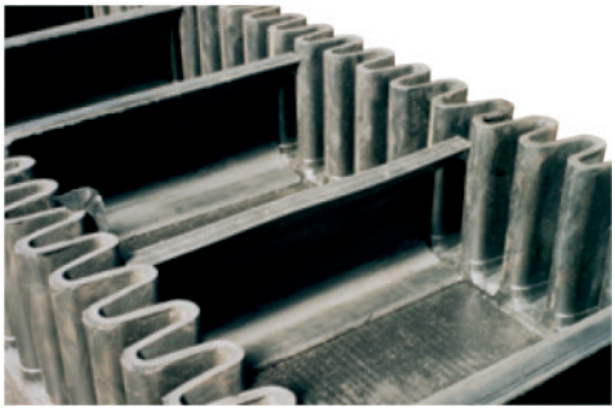

Fig. 2. Belt for application on high angle (vertical) conveyors
Rys. 2. Taśma przenośnika o dużym kącie nachylenia (pionowego)
Source: Ivchenko V.N., Davydov C.B., Kurov C.B., Babay V.Ya.: Opyt ekspluatatsii konveyyerov s podvesnoy lentoy [Operating experience with overhead belt conveyors]. Gornyy zhurnal [Mining journal] No. 3, 2003.

High angle (vertical) conveyors have a number of advantages over the use of conventional belt conveyors in particular, as well as to the application of groups of different types of transporting machines and auxiliary devices [4, 5].

The main advantage of these conveyors is saving valuable production space. For example, if the task is to raise the conveyed material to a height of 5 m, when using conventional belt conveyors with an angle of inclination of 18 degrees we need about 50 square meters of production area taking into account passes around the equipment, while conveying to a height of 10 m, space is required for about 100 square meters. When using steeply inclined conveyor at an angle 90 degree, required space in a production area in both cases is 20 square meters, because required space for these constructions doesn't depend directly on conveyor height [1].

Figure 3 shows the relationship of the space required and lifting height.

Figure 4 illustrates the relationship of production volumes occupied by different types of equipment.

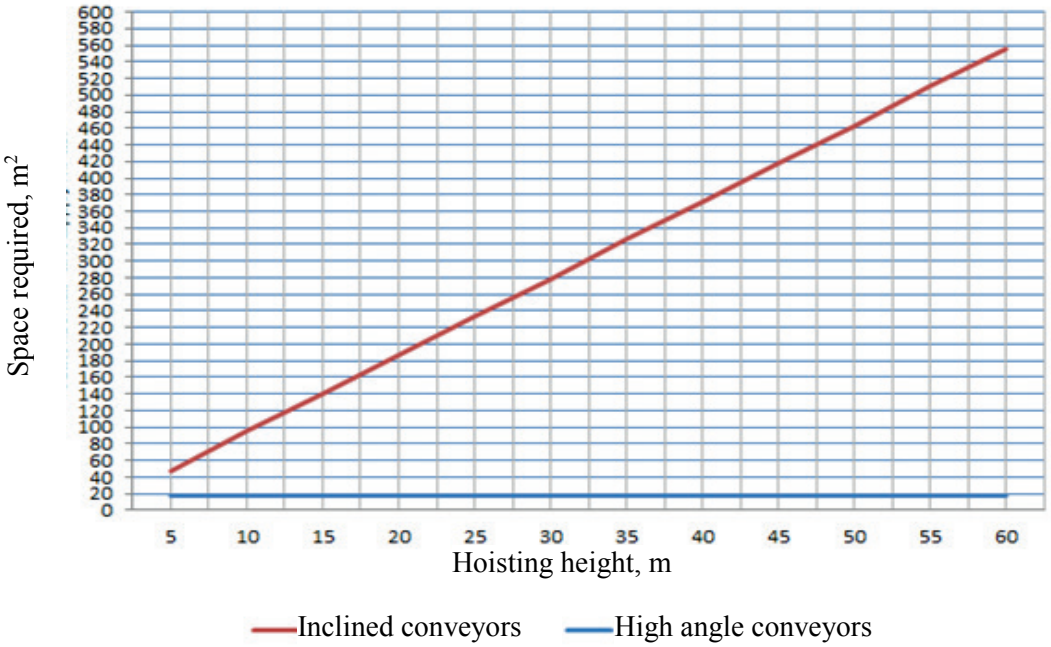

Fig. 3. Relationship of the space required and lifting height of inclined and high angle conveyors
Rys. 3. Zależność między wymaganą przestrzenią roboczą a wysokością transportu przenośników skośnych i z dużym kątem nachylenia
Source: Own elaboration.

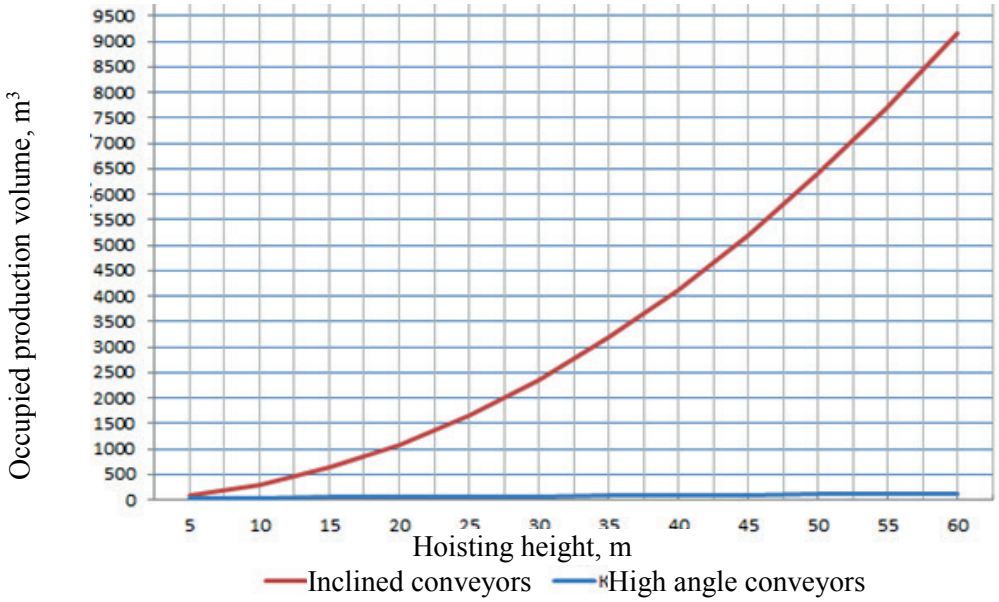

Fig. 4. Relationship of conveyor height and production volumes occupied by inclined and high angle conveyors.
Rys. 4. Zależność między wysokością przenośnika a zajmowaną przestrzenią roboczą przez przenośniki skośne i z dużym kątem nachylenia
Source: Own elaboration.

Figure 5 shows the relationship of weight and height of inclined and high angle conveyors.

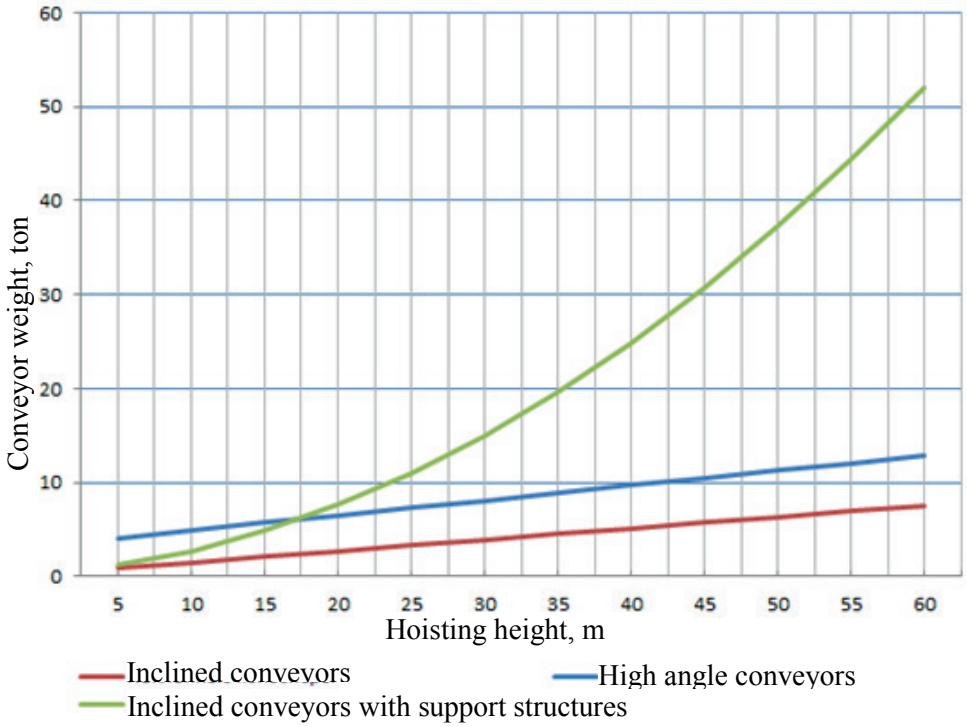

Fig. 5. The relationship of weight and height of inclined and high angle conveyors.
Rys. 5. Zależność między masą a wysokością przenośników skośnych i z dużym kątem nachylenia
Source: Own elaboration.

Another equally important advantage of using high angle conveyors is the absence of overloading of the material. Overloading of the material during transportation is undesirable (unless it is required by technology), because during overloading it is required coordinated work of delivery and outfeed conveying equipment, the overload zone for guiding the transported product stream requires a bunker; due to the high dust content it usually requires the use of aspiration systems. In addition, during overload the transported material is exposed to mechanical stress, damage and grind [8].

Horizontal section of high angle conveyor is the same as conventional horizontal conveyor. Vertical sections are more appropriate to compare with belt or chain elevator. However, high angle (vertical) conveyors have a number of advantages. They don't have chains that can wear out, abrade and break down. Moreover, the transported material has no contact with metal buckets, since they are not in the construction, and the material is located in main rubberized fabric belt or rubberized transverse profile. Furthermore, the transverse partition fastened without using the fasteners, they are fixed by means of cold or hot vulcanization, which makes the point of attachment elastic, conducive damping dynamic loads transmitted from the conveyed material to the belt, which in turn leads to the durability of these sites [9].

Nowadays high angle (vertical) conveyors more widely used at production sites, including enrichment plants, especially for renovations aimed at improving the productivity of the enterprise in general. At the moment, high angle conveyors are manufactured with capacity up to 200 m^3/h, with belt width up to 2000 mm, with a lifting height of 100 m and a total length of the conveyor belt up to 500 m. The manufacture of such belts is engaged in a number of enterprises on the territory of Russia and abroad. The most famous manufacturers are Metso Minerals, Kone, Paakkola Conveyors, RUSNEO, Kurgan Conveyor Equipment Plant, and others.

3. Overhead belt conveyors

Conveyors with an overhead belt have a much longer belt service life due to the absence of its lateral displacements and contact with the idlers, they are characterized by higher productivity, ease of maintenance of the set configuration of the route, so they are able to solve typical disadvantages of conventional belt conveyors. However, conveyors with an overhead belt have limited applicability because of the relatively low belt speed (2 m/s) and the difficulty of providing a stretch over the course of 1 meter. Therefore, improving the technical performance of conveyors with overhead belt and eliminating the above drawbacks is an urgent task.

Application of a conveyor with overhead belt and stationary disk-type support rollers instead of conveyors with bogie wheels, will remove the restriction on the stroke of the tension device,

will increase 2-3 times the maximum belt speed and reduce 3-5 times the mass of the rotating parts in the middle of the conveyor line [10]. Conveyor with overhead belt is shown on Figure 6.

Fig. 6. Conveyor with an overhead belt
Rys. 6. Przenośnik z taśmą podwieszaną
Source: Ivchenko V.N., Davydov C.B., Kurov C.B.: Besprosypnyye lentochnyye konveyyery novogo pokoleniya s podvesnoy lentoy [Non-spillage conveyors of a new generation with overhead belt]. Gornyye mashiny i avtomatika [Mining machinery and equipment] No. 7, 2004.

4. Special types of intermediate drives for belt conveyors

Application of special conveyor types requires attention on their drives.

It is proposed to use magnetic forces as an additional driving force to improve the ability of specific traction effort of intermediate belt drives. In this case, this is achieved by providing the upper branch of the belt with permanent magnets which interact with soft magnetic conveyor belt. The scheme of magneto frictional drive is shown on Figure 7.

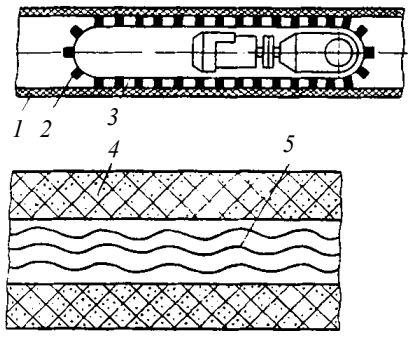

Fig. 7. Magneto frictional drive scheme: 1 – magnetic belt; 2 – magnetic blocks; 3 – tractive chain or belt; 4 – magnetic belt filler; 5 – side irons
Rys. 7. Schemat napędu magnetofrykcyjnego: 1 – taśma magnetyczna; 2 – klocki magnetyczne; 3 – łańcuch lub pas trakcyjny; 4 – wypełnienie taśmy magnetycznej; 5 – boczne elementy stalowe
Source: Vasil'yev K.A., Nikolayev A.K., Sazonov K.G.: Transportnyye mashiny i gruzopod"yemnoye oborudovaniye obogatitel'nykh fabric [Transport machinery and lifting equipment of enrichment plants]. SPb: Nauka 2006.

Magneto frictional drive, the design of which was developed in the Donetsk Industrial Institute under the guidance of professor I.G.Shtokman, passed industrial tests in 1972 on one of the mines of the production association "Krasnoarmeyskugol" and confirmed its performance in a coal mine. Specific tractive power (kN/m^2) of magneto frictional drive due to the action of magnetic forces has increased by 0,46 kN, which reduced the length of the intermediate drive and extend the scope of multidrive belt conveyors by use in inclined workings since the magnetic force provides consistent gain of traction of intermediate drive at any angle of the conveyor inclination.

The development of this direction was the patent No. 2482043 (Figure 8), the author is Yu.D. Tarasov, professor of mining transport machines department of Saint-Petersburg Mining University, which offered permanent magnets, which are made of rollers anchoring the material [11].

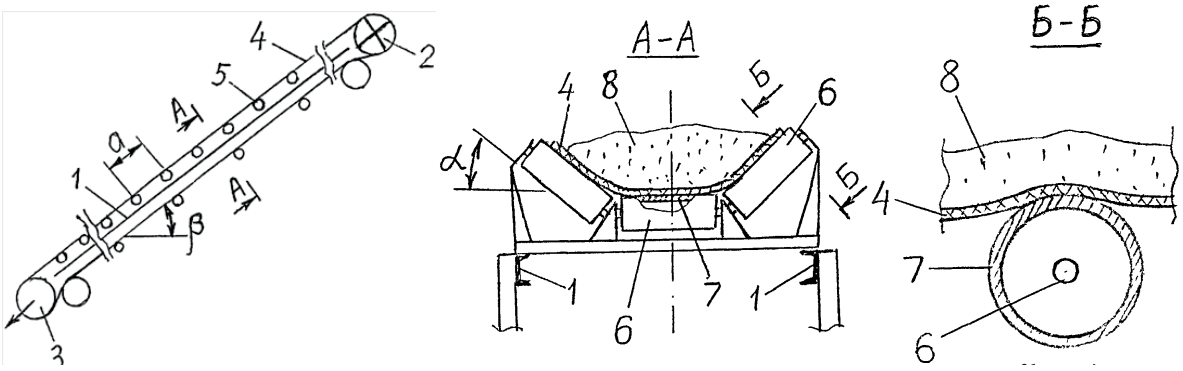

Fig. 8. High angle magneto frictional conveyor
Rys. 8. Przenośnik magnetofrykcyjny z wysokim kątem nachylenia
Source: Patent RUS No. 2482043. Tarasov Yu.D.: High angle magneto frictional belt conveyor.

Another type of intermediate linear belt drive is a vacuum drive. The design of the vacuum drive is quite simple and is made using serial drive units of belt conveyors. Transverse blind grooves-channels are made on the working surface of the traction drive belt, wherein during operation the drive a vacuum is produced by using liquid-ring vacuum pump. Their specific tractive capacity at 30-50 times, depending on type and belt width, exceeds (at a vacuum of 40 kPa) specific traction capability of conventional belt conveyors [3]. Therefore, the maximum length of the vacuum drive is 20-30 meters, which allows to put one or two back-up drives in the pipeline space in addition to the estimated number of drives, which increases the reliability of the conveyor, availability factor which is equal to the coefficient of readiness of conventional belt conveyor. Additional traction provided by the vacuum drive, remains the same at any angle of the conveyor inclination, which significantly expands the scope of the multidrive conveyors.

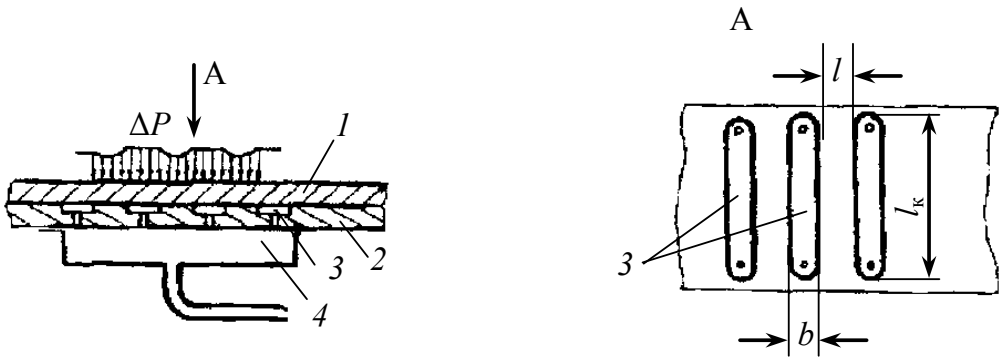

Fig. 9. Scheme of intermediate vacuum belt drive: 1 – carrying belt; 2 – vacuum drive belt; 3 – grooves-channels; 4 – a low-pressure chamber with the sides of the low friction material; ΔP – the pressure difference between the atmospheric pressure and the residual between belts

Rys. 9. Schemat pośredniego, próżniowego napędu taśmowego: 1 – taśma nośna; 2 – taśma napędu próżniowego; 3 – rowki-kanały; 4 – komora niskiego ciśnienia o bokach wykonanych z materiału o niskim współczynniku tarcia; ΔP – różnica ciśnienia atmosferycznego i resztkowego między pasami

Source: Vasil'yev K.A., Nikolayev A.K., Sazonov K.G.: Transportnyye mashiny i gruzopod"yemnoye oborudovaniye obogatitel'nykh fabric [Transport machinery and lifting equipment of enrichment plants]. SPb: Nauka 2006.

New design of intermediate linear drive for belt conveyors was developed at Department of mining transport machines of National Mineral Resources University [12,13]. The developed version of the intermediate drive (Figure 10) [12] contains beneath the load-carrying branch belt 3 closed on the drive 6 and the tension 1 drum drive belt 4, the upper branch of which is placed under the load-bearing branch of the conveyor belt 3 and is based on its idlers or straight roller 5. In the middle of each section between the side edge of the carrying rollers of the conveyor belt and under the side edge has a drive belt 14 and pressure rollers 7, with the possibility of rotation about fixed axes 16 and 19, outer portion 11 and 8 which have a flat shape oriented with its sides parallel to the plane of the conveyor and drive belts. Between the outer flat parts fixed axis placed on the racks 10 and the conveyor frame 18, flat bracket 9 and 17with boards normally oriented to their flat part. Moreover the flat parts with flat outer bracket portions 11 and 8 of axes 16 and 19 are connected by bolts 13 with push nuts 12. The pressure rollers are made with elastic rims 22 and 23, and fitted on the outer side facing toward each other the projections 15 and 20 with the possibility of interaction with the ends of the conveyor and drive belts. The thickness of the flat portion of the brackets is selected considering the allowable design pressure between the pressure rollers and the drive and conveyor belts.

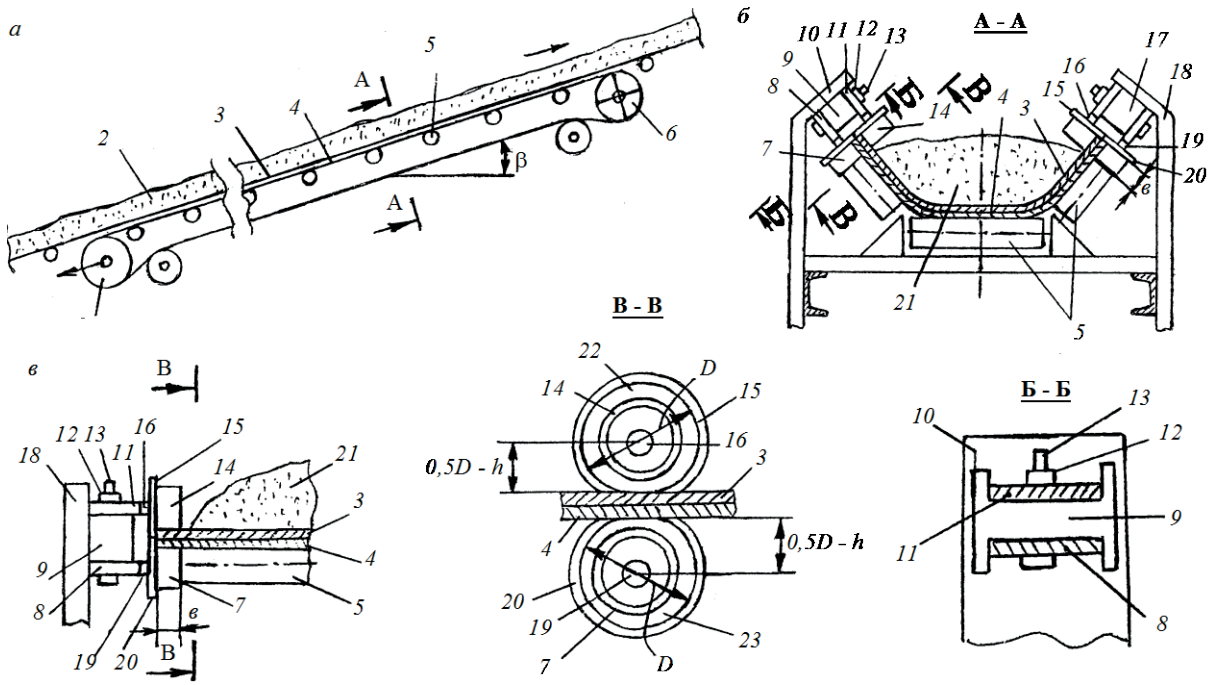

Fig. 10. Intermediate linear drive with pressure rollers
Rys. 10. Pośredni napęd liniowy z rolkami dociskowymi
Source: Patent RUS No. 2487071: Tarasov Yu.D., Trufanova I.S.: Promezhutochnyy lineynyy privod lentochnogo konveyyera [Intermediate linear drive for belt conveyor] 2013.

5. Conclusions

To summarize, it should be mentioned that there are much more special designs of belt conveyors. It is difficult to overview all of them within one article. In recent days companies-manufacturers, engineers and scientists try to solve problems for particular mining enterprises, taking into account theirs needs and special working conditions.

High angle conveyors have a number of advantages over the use of conventional belt conveyors, for example, saving production space, absence of overloading the material.

It is considered improving design of the belt conveyors through the development of the intermediate drive construction as the optimal solution of the traction transferring problems, with increased traction transferring efficiency of the intermediate linear drive on inclined and curving route sections, and especially in the inclined conveyor.

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Omówienie

W artykule przedstawiono różne typy przenośników taśmowych i ich pośrednie przekładnie, takie jak przenośniki z dużym kątem nachylenia, pionowe, z napędem liniowym i ciśnieniowe, z napędem magnetofrykcyjnym i systemem próżniowym. Zastosowanie tych przenośników jest odpowiednie w trudnych warunkach, kiedy instalacja konwencjonalnego przenośnika jest nieracjonalna lub nawet niemożliwa. Wspomniane typy przenośników mają dużo zalet w porównaniu do konwencjonalnych przenośników taśmowych.